CLAIMS

1. A transport unit for moving a microelectronic workpiece, comprising:

a housing having a guide member configured to move linearly along a linear track;

a vertical member extending from said housing, said vertical member being carried by said housing to move along a vertical path;

an arm member extending from said vertical member, the arm member being carried by the vertical member to rotate about a first vertical axis, and the arm member having an end effector disposed for holding a workpiece and a first rotary actuator connected to said end effector for rotating said end effector about a horizontal axis.

2. The transport unit according to claim 1, further comprising a second rotary actuator connected to said vertical member for rotating said vertical member and said arm member about the first vertical axis.

3. The transport unit according to claim 2, wherein said arm member includes a first section and a second section, said first section rotationally carried by said vertical member at a first end thereof, and said first section rotationally carrying said second section at a second end thereof, said second section carrying said end effector, and wherein said transport unit further includes a third rotary actuator connected to said first and second sections for rotating said second section with respect to said first section about a second vertical axis.

4. The transport unit according to claim 1 further comprising a lift actuator carried by said housing and connected to said vertical member to vertically move said vertical member with respect to said housing.

5. The transport unit according to claim 1 wherein said housing comprises a linear bearing configured to be coupled to a rail of an external guide system and an electromagnet for transporting said transport unit along the rail.

6. The transport unit according to claim 1, wherein said end effector includes a horizontally extending member having at least one protruding member arranged for pressing an edge of a workpiece overlying said horizontally extending member, and a movable member, selectively movable to press the edge of the workpiece against the protruding member to grip said workpiece on said horizontally extending member.

7. The transport unit according to claim 6, wherein said horizontally extending member comprises a Y-shaped paddle and said at least one protruding body comprises two pins, each pin extending perpendicularly from one leg of said Y-shaped paddle.

8. The transport unit according to claim 6, wherein said movable member comprises a plunger arranged to press the edge of the workpiece, said plunger having a angled surface pressing said edge of said workpiece.

9. The transport unit according to claim 6 wherein said at least one protruding member comprises two spaced apart pins, and wherein said pins include radially extending flanges at end of said pins spaced from said horizontally extending member.

10. The transport unit according to claim 9 wherein said pins include an intermediate base portion having a surface which tapers toward a receiving surface of said horizontally extending member which is closest to said workpiece, such that said workpiece is supported on an edge thereof having its bottom surface spaced from a top surface of said receiving surface.

11. The transport unit according to claim 1, further comprising a workpiece presence sensor mounted to said effector, the sensor generating a signal corresponding to the presence of a workpiece on the effector.

12. The transport unit according to claim 11, wherein said effector comprises first and second upstanding portions which are arranged to press spaced apart locations on the edge of the workpiece to grip said workpiece between said first and second portions, one of said first and second portions being selectively movable to engage or disengage the workpiece from the effector.

13. The transport unit according to claim 12, wherein said first and second portions include retaining portions which overlie of the workpiece opposite a supporting surface of said end effector.

14. The transport unit according to claim 1, wherein said arm member includes:

a first section extending from said vertical member;

a second section extending from said first section, said second section rotationally connected to said first section, said second section carrying said first rotary actuator and said end effector; and

a second rotary actuator having a first portion connected to said first section and a second portion connected to said second section, and a rotary power source for rotating said first portion with respect to said second portion.

15. A system for moving workpieces, comprising:

a track assembly having first guide rail supported in a horizontal position;

a transport unit including a housing supported by said rail and guided for sliding movement along said rail, a vertical member extending from said housing, and an arm member extending from said vertical member, said arm member having an end effector for holding a workpiece, and a first rotary actuator connected to said end effector for rotating said end effector about a horizontal axis; and

a linear actuating system coupled to the track and the housing for moving the housing linearly along the track.

16. The system according to claim 15, wherein said transport unit further comprises a second rotary actuator connected to said vertical member for rotating said vertical member and said arm member about a first vertical axis.

17. The system according to claim 15, wherein said arm member includes a first section and a second section, said first section carried by said vertical member at a first end thereof, and said first section rotationally carrying said second section at a second end thereof, said second section carrying said end effector, and said transport unit further including a third rotary actuator connected to said first and second sections for rotating said second section with respect to said first section about a second vertical axis.

18. The system according to claim 15, wherein said transport unit further comprises a lift actuator carried by said housing and connected to said vertical member to vertically move said vertical member with respect to said housing.

19. The system according to claim 15, wherein said housing comprises at least one linear bearing for receiving said rail.

20. The system according to claim 15, wherein said linear actuating system comprises an electromagnet for transporting said transport unit along said rail.

21. A system for moving workpieces, comprising:

a track assembly having a guide rail system supported in a horizontal position, the guide rail system including a first rail on one side of the track and a second rail on another side of the track;

a first transport unit including a first housing having a first guide member slidably coupled to said first rail, a first vertical member carried by said first housing to move vertically, a first arm member carried by said first vertical member, and a first end effector

for holding a workpiece carried by said first arm member, said first end effector being elevated from first said arm member;

a second transport unit including a second housing having a second guide member slidably coupled to said second rail, a second vertical member carried by said second housing to move vertically, a second arm member carried by said second vertical member, and a second end effector for holding a second workpiece carried by said second arm member, said second end effector being elevated from said second arm member; and

wherein said first end effector is positionable to be superimposed over said second end effector so that the first workpiece held by said first transport unit can pass over the second workpiece held by said second transport unit.

22. The system according to claim 21 wherein said first transport unit includes a first wrist tube connected between said first end effector and said first arm member for allowing rotation of said first end effector about a vertical axis with respect to said first arm member.

23. The system according to claim 22, further comprising a cap member connected between said first end effector and said first wrist tube to elevate said first end effector from said first arm member.

24. The system according to claim 21 wherein said first effector includes raised pad areas, a vacuum channel, and a plurality of ports extending from said vacuum channel and passing through said raised pad areas to be exposed on a top side thereof, said ports for exerting vacuum pressure to an overlying wafer to hold said wafer to said end effector; and

a plurality of locator pins, wherein one or more locator pins are adjacent each of said raised pad areas to precisely locate a wafer onto said raised pad areas, and wherein said raised pad areas have a shape and orientation to contact said wafer only on a narrow edge region thereof.

25. A robot arm end effector for holding a workpiece, comprising:

a paddle having an elongated structure with a plurality of spaced-apart raised areas on a first surface thereof for contacting a surface of a workpiece to be supported thereby, said raised areas each having at least one opening and a conduit connecting said openings to a source of vacuum; and

wherein said raised areas are arranged and configured to circumscribe portions of an annular area for contacting an outer edge of the workpiece.

26. The end effector according to claim 25, further comprising locator pins arranged adjacent to said raised areas to guide the workpiece onto said raised areas.

27. The end effector according to claim 26, wherein said locator pins include angled surfaces for guiding the workpiece onto said raised areas.

28. The end effector according to claim 25, wherein said elongated structure comprises two prongs, one of said raised areas carried by each of said prongs at a distal end of said prongs.

29. The end effector according to claim 25, wherein said conduit comprises an open channel formed into a surface of said paddle and a plate-closeout for enclosing said channel.

30. The end effector according to claim 25, wherein said elongated surface comprises a Y-shaped structure having two prongs and a base region, said raised areas being shaped in plan as portions of a circle and said portions located at distal ends of said prongs and at said base region, respectively, and said conduit comprises a channel formed into said Y-shaped structure beneath said first surface, and further comprising a plurality of locator pins, wherein each locator pin is located adjacent to said raised areas and outside of said circle to guide a circular workpiece onto said raised areas, and wherein a vacuum applied through said openings holds said workpiece to said raised areas.

31. A transport unit for manipulating a microelectronic workpiece, comprising:

a base having a guide member configured to move along an elongated track;

a linear actuator and an upright member carried by the base, wherein the linear actuator is coupled the upright member to move the upright member along an elevation axis;

an arm member carried by the upright member, the arm member extending at an angle relative to the elevational axis;

an end-effector coupled to the arm member, the end-effector being configured to releasably hold a microelectronic workpiece;

a first rotational actuator operatively coupled to the end-effector to rotate the end-effector about a flip axis in a manner that moves the workpiece between a face-up position and a face-down position; and

a second rotational actuator operatively coupled to at least one of the upright member and/or the arm member to rotate the arm member about the elevation axis.

32. The transport unit of claim 31, wherein the end-effector comprises an edge grip end-effector having a plurality of raised areas, an opening at each raised area, and a conduit for connecting each opening to a vacuum source, and wherein the raised areas are arranged on the end-effector in a circular pattern to contact a peripheral portion of the workpiece.

33. The transport unit of claim 32, wherein the circular pattern has a diameter of approximately 200mm to 300mm.

34. The transport unit of claim 31, wherein the base comprises a housing, the upright member comprises a vertical member, and the arm member comprises a first arm section coupled to the vertical member and a second arm section coupled to the first arm section.

35. A transport unit for handling a microelectronic workpiece, comprising:

a support structure having a guide member configured to be slidably attached to an elongated track;

a shaft member carried by the support structure at an angle to the elongated track, wherein the shaft member is coupled to a linear actuator to move the shaft member along a linear elevation path relative to the elongated track;

an arm member carried by the shaft member, the arm member projecting from the shaft member;

an edge-grip end-effector coupled to the arm member, the end-effector being configured to releasably engage only a peripheral portion of the microelectronic workpiece;

a first rotational actuator operatively coupled to the end-effector to rotate the end-effector about a generally horizontal axis in a manner that moves the workpiece between a face-up position and a face-down position; and

a second rotational actuator operatively coupled to at least one of the shaft member and/or the arm member to rotate the arm member about a first axis that is generally in the direction of the elevation path.

36. The transport unit of claim 35, wherein the end-effector comprises a paddle having pins arranged in a circular pattern to contact an edge portion of the workpiece, and wherein the pins have a top flange and an inclined lower portion that define a groove to receive the edge portion of the workpiece.

37. The transport unit of claim 35, wherein the end-effector comprises a paddle having a plurality of raised areas, an opening at each raised area, and a conduit for connecting each opening to a vacuum source, and wherein the raised areas are arranged on the end-effector in a circular pattern to contact a peripheral portion of the workpiece.

38. The transport unit of claim 37, wherein the circular pattern has a diameter of approximately 200mm to 300mm.

39. The transport unit of claim 35, wherein the support structure comprises a housing, the shaft member comprises a vertical member, and the arm member comprises a first arm section coupled to the vertical member and a second arm section coupled to the first arm section.

40. A transport system for transporting a microelectronic workpiece between processing stations, the transport system comprising:

a linear track having a first guide rail on a first side of the track; and

a first transport unit including a first base having a first guide member slidably attached to the first rail, a first upright member carried by the first base to move along a first elevation path at an angle relative to the track, a first arm member carried by the first upright member, and a first edge-grip end-effector carried by the first arm member, wherein the first upright member is linearly moveable along the first elevation path, the first arm member is rotatable about a first elevation axis generally normal to the first arm member, and the end-effector is rotatable about a first flip axis generally normal to the first elevation axis.

41. The transport system of claim 40, wherein the first end-effector comprises a first edge grip end-effector configured to contact a peripheral portion of the workpiece.

42. The transport system of claim 40, wherein the first end-effector comprises a first edge grip end-effector having a plurality of raised areas, an opening at each raised area, and a conduit for connecting each opening to a vacuum source, and wherein the raised areas are arranged on the first end-effector in a circular pattern to contact a peripheral portion of the workpiece.

43. The transport system of claim 42, wherein the circular pattern has a diameter of approximately 200mm to 300mm.

44. The transport system of claim 40, wherein the first base comprises a housing, the first upright member comprises a first vertical member, and the first arm

member comprises a first arm section coupled to the first vertical member and a second arm section coupled to the first arm section.

45. The transport system of claim 40, further comprising an electromagnetic linear actuator coupled to the linear track and the first base of the first transport unit, the electromagnetic linear actuator having a plurality of permanent magnets arranged in a line along the track and an electromagnet attached to the first base.

46. A transport system for transporting a microelectronic workpiece between processing stations within a processing chamber, the transport system comprising:

a linear track having a first guide rail on a first side of the track and a second guide rail on a second side of the track;

a first transport unit including a first support structure having a first guide member slidably attached to the first rail, a first elevation member projecting from the first support structure, a first arm member carried by the first elevation member, and a first end-effector carried by the first arm member, wherein the first arm member is rotatable about a first elevation axis generally normal to the first arm member and the end-effector is rotatable about a first flip axis generally normal to the first elevation axis; and

a second transport unit including a second support structure having a second guide member slidably attached to the second rail, a second elevation member carried by the second support structure, a second arm member carried by the second elevation member, and a second end-effector carried by the second arm member, wherein the second arm member is rotatable about a second elevation axis generally normal to the second arm member and the second end-effector is rotatable about a second flip axis generally normal to the second elevation axis.

47. The transport system of claim 46, wherein the first and second end-effectors comprise first and second edge grip end-effectors, respectively, and wherein the first and second edge grip end-effectors are configured to contact a peripheral portion of the workpiece.

48. The transport system of claim 46, wherein:

the first end-effector comprise a first edge grip end-effector having a plurality of raised areas, an opening at each raised area, and a conduit for connecting each opening to a vacuum source, and wherein the raised areas are arranged on the first end-effector in a circular pattern to contact a peripheral portion of the workpiece; and

the second end-effector comprise a second edge grip end-effector having a plurality of raised areas, an opening at each raised area, and a conduit for connecting each opening to a vacuum source, and wherein the raised areas are arranged on the second end-effector in a circular pattern to contact a peripheral portion of the workpiece.

49. The transport system of claim 48, wherein the circular pattern on the first and second end-effectors each have a diameter of approximately 200mm to 300mm.

50. The transport system of claim 46, wherein:

the first support structure comprises a first housing, the first elevation member comprises a first vertical member, and the first arm member comprises a first arm section coupled to the first vertical member and a second arm section coupled to the first arm section; and

the second support structure comprises a second housing, the second elevation member comprises a second vertical member, and the second arm member comprises a first arm portion coupled to the second vertical member and a second arm portion coupled to the first arm portion.

51. The transport system of claim 46, further comprising:

a first electromagnetic linear actuator coupled to the first side of the track and the first support member of the first transport unit, the first electromagnetic linear actuator having a plurality of first permanent magnets arranged in a line along the first side of the track and a first electromagnet attached to the first support structure; and

a second electromagnetic linear actuator coupled to the second side of the track and the second support member of the second transport unit, the second electromagnetic

linear actuator having a plurality of second permanent magnets arranged in a line along the second side of the track and a second electromagnet attached to the second support structure.

52. An apparatus for processing a microelectronic workpiece, the apparatus comprising:

a processing chamber having a workpiece conveyor path, a first processing module on one side of the conveyor path, and a second processing module on an opposing side of the conveyor path, wherein the first processing module includes a first plurality of processing stations and the second processing module includes a second plurality of processing stations;

an elongated track in the processing chamber, the elongated track extending along the conveyor path, and the elongated track having a first guide rail on a first side of the track facing the first processing module; and

a first transport unit including a first support structure having a first guide member slidably attached to the first rail, a first upright member carried by the first support structure, a first arm member carried by the first upright member, and a first end-effector carried by the first arm member, wherein the first arm member is rotatable about a first elevation axis generally normal to the first arm member, and the end-effector is rotatable about a first flip axis generally normal to the first elevation axis.

53. An apparatus for processing a microelectronic workpiece, the apparatus comprising:

a processing chamber having a workpiece conveyor path, a first processing module on one side of the conveyor path, and a second processing module on an opposing side of the conveyor path, wherein the first processing module includes a first plurality of processing stations and the second processing module includes a second plurality of processing stations;

an elongated track in the processing chamber, the elongated track extending along the conveyor path, and the elongated track having a first guide rail on a first side of the track facing the first processing module and a second guide rail on a second side of the track facing the second processing module;

a first transport unit including a first support structure having a first guide member slidably attached to the first rail, a first upright member carried by the first support structure, a first arm member carried by the first upright member, and a first end-effector carried by the first arm member, wherein the first arm member is rotatable about a first elevation axis generally normal to the first arm member, and the end-effector is rotatable about a first flip axis generally normal to the first elevation axis; and

a second transport unit including a second support structure having a second guide member slidably attached to the second rail, a second upright member carried by the second support structure, a second arm member carried by the second upright member, and a second end-effector carried by the second arm member, wherein the second arm member is rotatable about a second elevation axis generally normal to the second arm member and the end-effector is rotatable about a second flip axis generally normal to the second elevation axis.